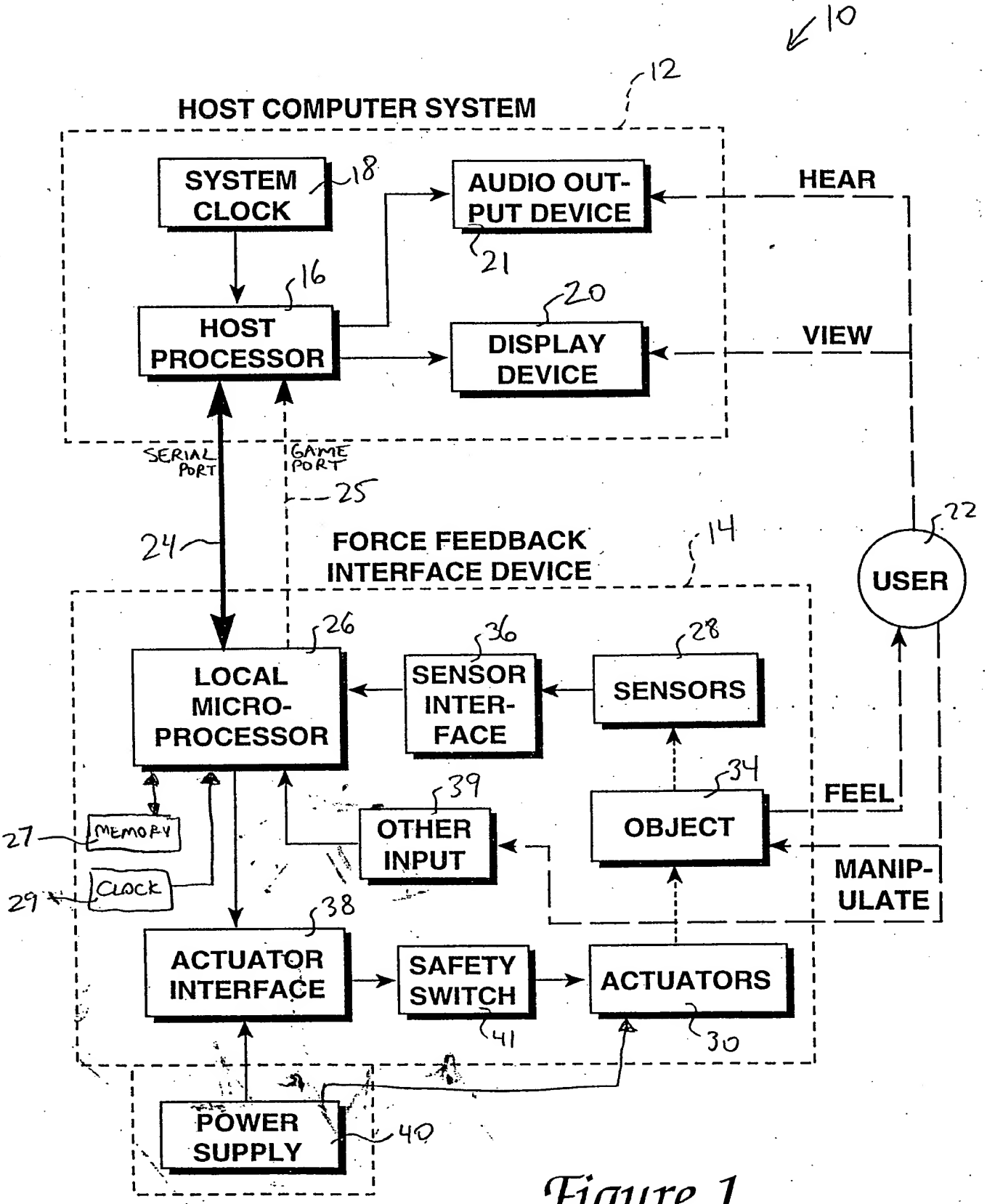
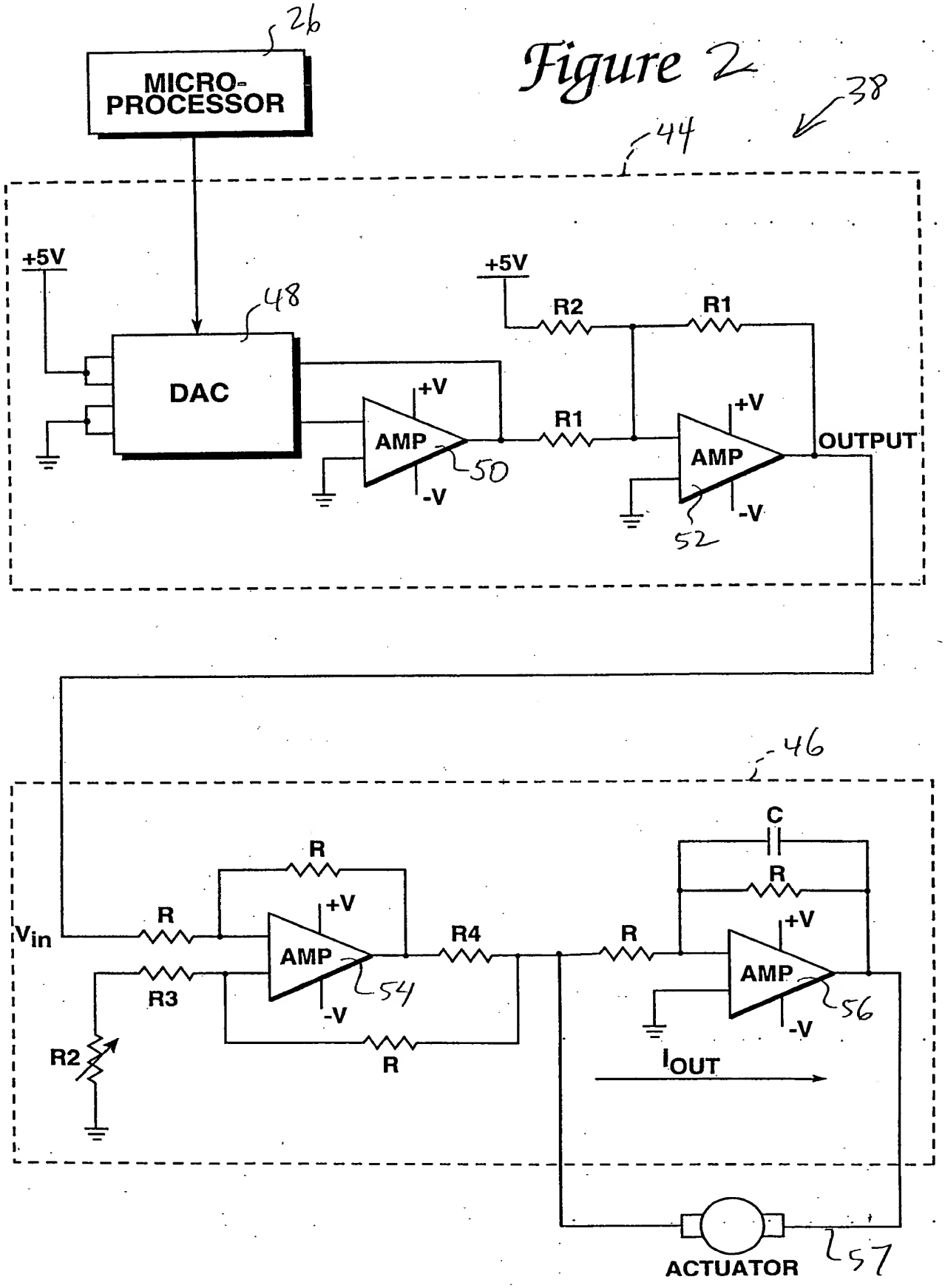

10
12
HOST COMPUTER SYSTEM
SYSTEM CLOCK
18
AUDIO OUT-PUT DEVICE
21
HEAR
16
HOST PROCESSOR
20
DISPLAY DEVICE
VIEW
SERIAL PORT
GAME PORT
25
24
FORCE FEEDBACK INTERFACE DEVICE
14
22
USER
26
LOCAL MICRO-PROCESSOR
36
SENSOR INTER-FACE
28
SENSORS
27
MEMORY
39
OTHER INPUT
34
OBJECT
FEEL
29
CLOCK
MANIP-ULATE
38
ACTUATOR INTERFACE
SAFETY SWITCH
41
ACTUATORS
30
POWER SUPPLY
40

Figure 1

Figure 2


26
MICRO-PROCESSOR
38
44
+5V
48
DAC
+V
AMP
-V
50
R1
+5V
R2
R1
+V
AMP
-V
52
OUTPUT
46
R
R
Vin
+V
AMP
-V
54
R4
R3
R2
R
C
R
R
+V
AMP
-V
56
IOUT
ACTUATOR
57

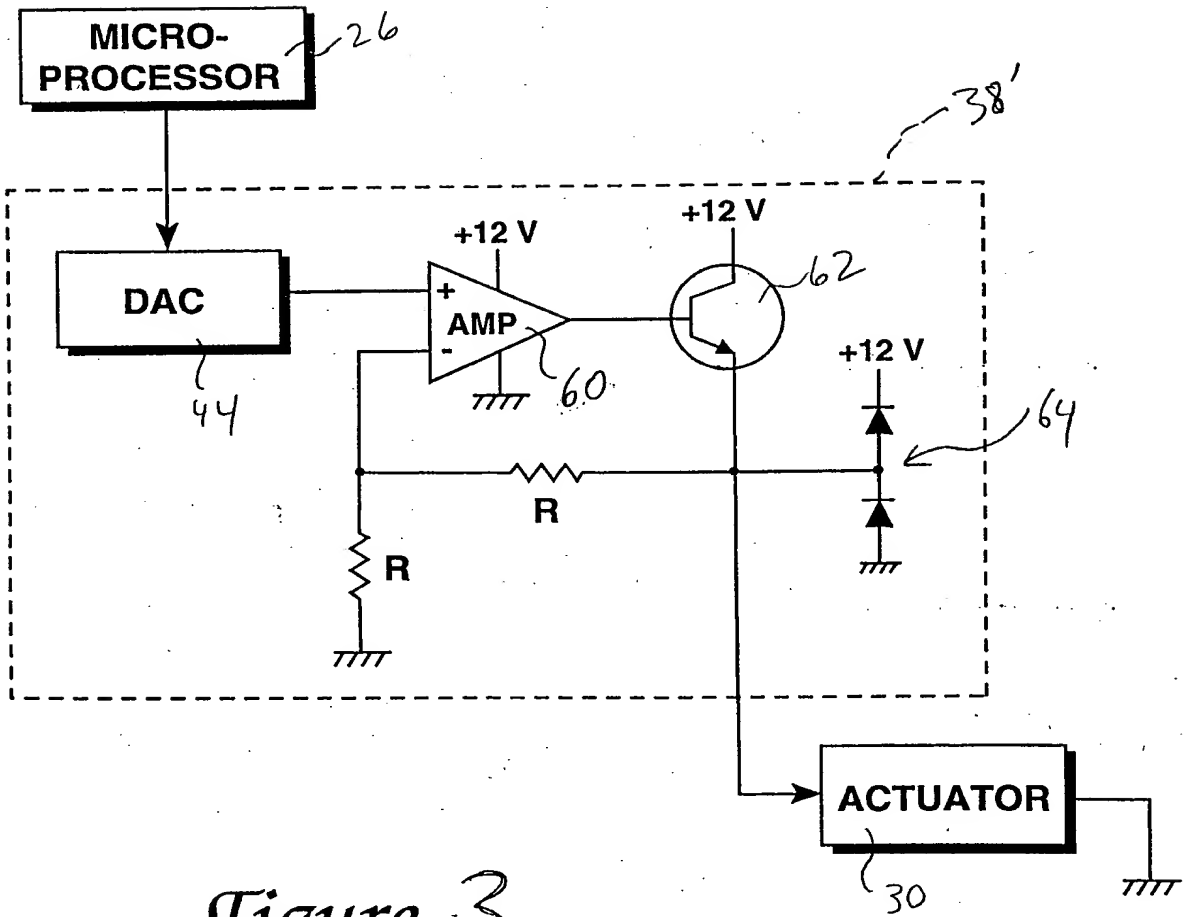

MICRO-
PROCESSOR
26
38'
DAC
44
+12 V
AMP
60
+12 V
62
+12 V
64
R
R
ACTUATOR
30

Figure 3

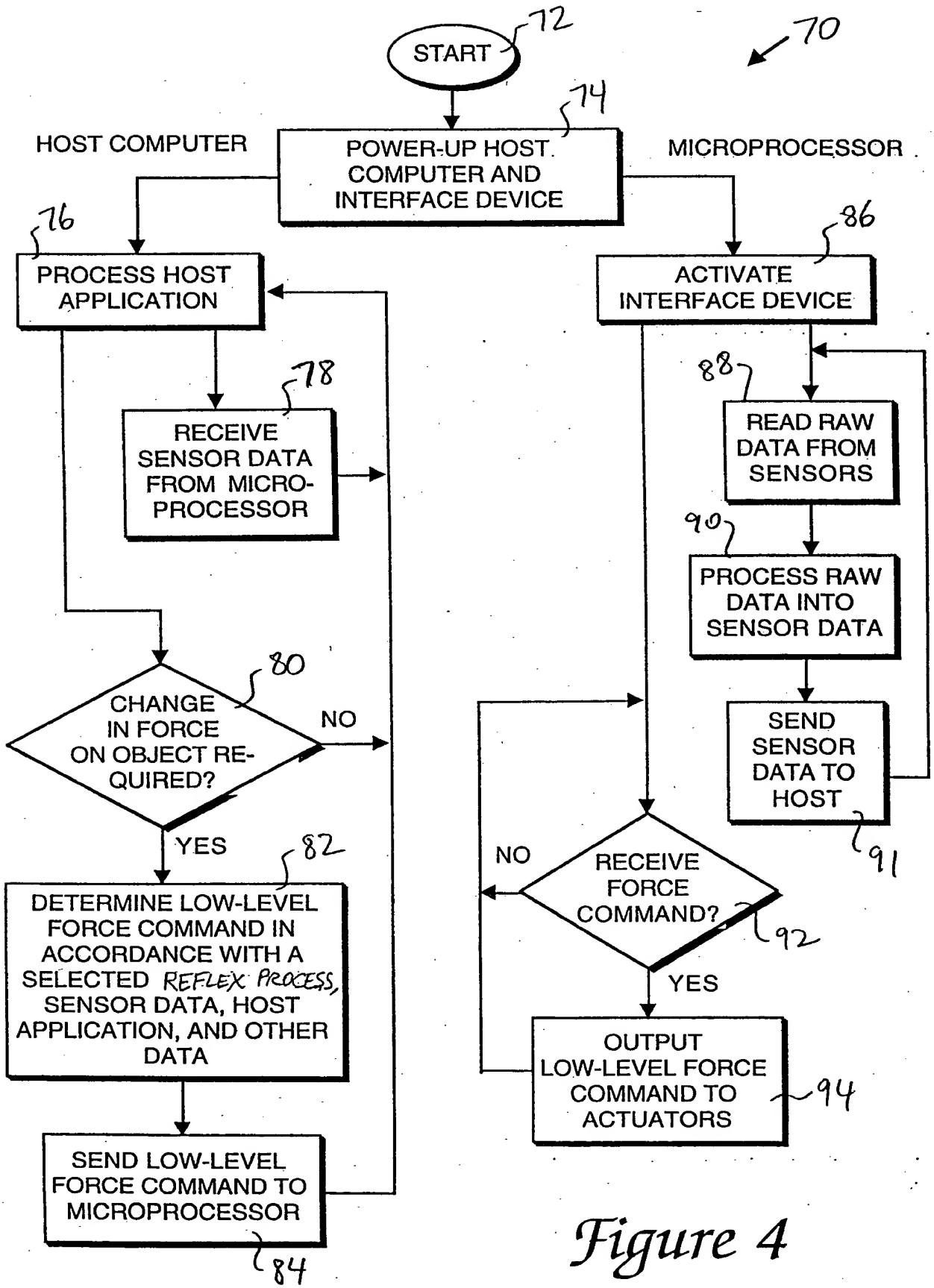

START
72
70
74
HOST COMPUTER
POWER-UP HOST COMPUTER AND INTERFACE DEVICE
MICROPROCESSOR
76
PROCESS HOST APPLICATION
86
ACTIVATE INTERFACE DEVICE
78
RECEIVE SENSOR DATA FROM MICRO-PROCESSOR
88
READ RAW DATA FROM SENSORS
90
PROCESS RAW DATA INTO SENSOR DATA
80
CHANGE IN FORCE ON OBJECT RE-QUIRED?
NO
YES
SEND SENSOR DATA TO HOST
91
82
DETERMINE LOW-LEVEL FORCE COMMAND IN ACCORDANCE WITH A SELECTED REFLEX PROCESS, SENSOR DATA, HOST APPLICATION, AND OTHER DATA
NO
RECEIVE FORCE COMMAND?
92
YES
SEND LOW-LEVEL FORCE COMMAND TO MICROPROCESSOR
84
OUTPUT LOW-LEVEL FORCE COMMAND TO ACTUATORS
94

Figure 4

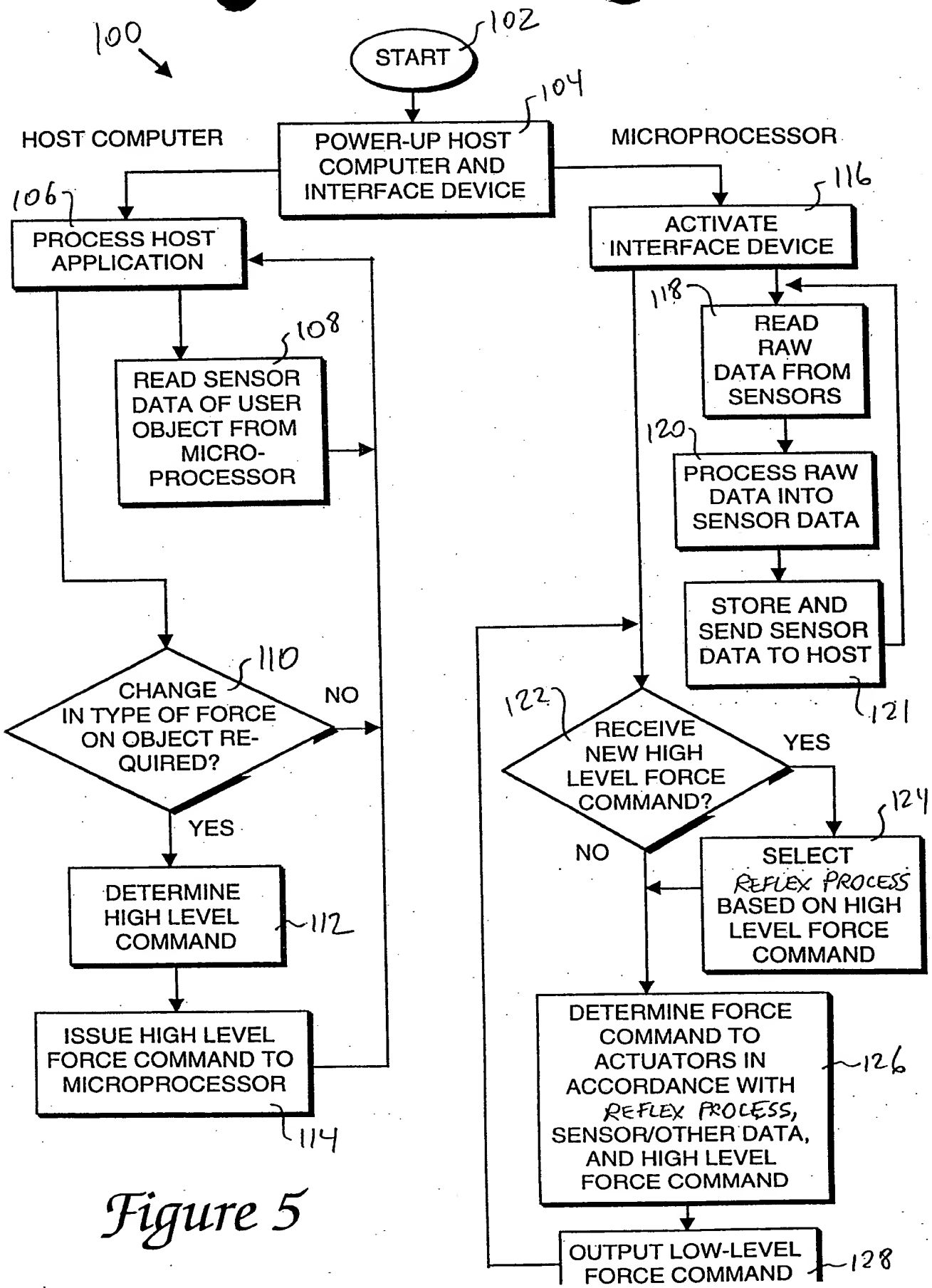

100
START
102
HOST COMPUTER
POWER-UP HOST COMPUTER AND INTERFACE DEVICE
104
MICROPROCESSOR
106
PROCESS HOST APPLICATION
ACTIVATE INTERFACE DEVICE
116
118
READ RAW DATA FROM SENSORS
108
READ SENSOR DATA OF USER OBJECT FROM MICRO-PROCESSOR
120
PROCESS RAW DATA INTO SENSOR DATA
STORE AND SEND SENSOR DATA TO HOST
121
110
CHANGE IN TYPE OF FORCE ON OBJECT RE-QUIRED?
NO
122
RECEIVE NEW HIGH LEVEL FORCE COMMAND?
YES
124
YES
NO
SELECT REFLEX PROCESS BASED ON HIGH LEVEL FORCE COMMAND
DETERMINE HIGH LEVEL COMMAND
112
DETERMINE FORCE COMMAND TO ACTUATORS IN ACCORDANCE WITH REFLEX PROCESS, SENSOR/OTHER DATA, AND HIGH LEVEL FORCE COMMAND
126
ISSUE HIGH LEVEL FORCE COMMAND TO MICROPROCESSOR
114
OUTPUT LOW-LEVEL FORCE COMMAND
128

Figure 5

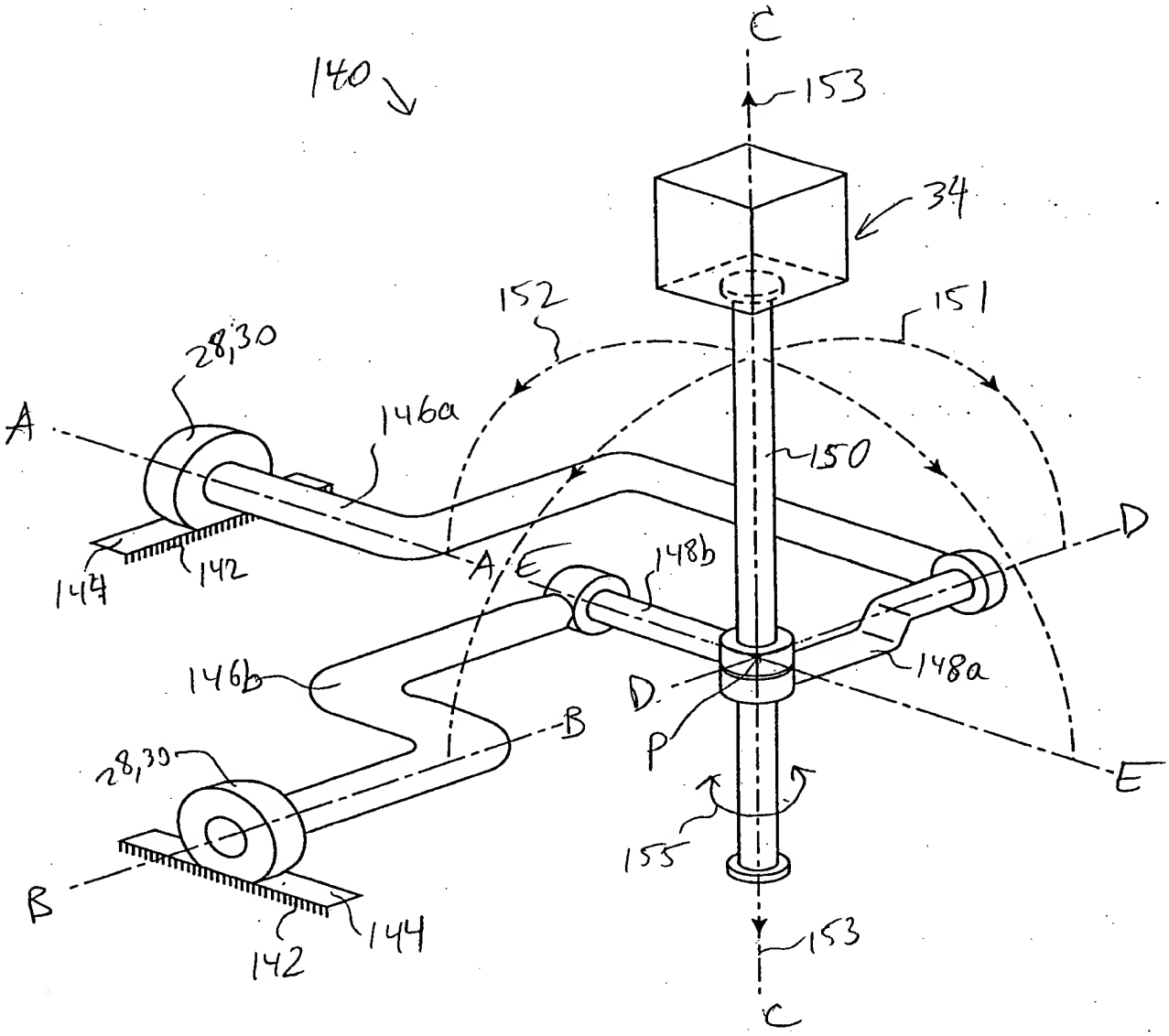

140
C
153
34
152
151
28,30
A
146a
150
D
144
142
A
E
148b
146b
148a
D
B
P
28,30
E
155
B
144
142
153
C

Figure 6

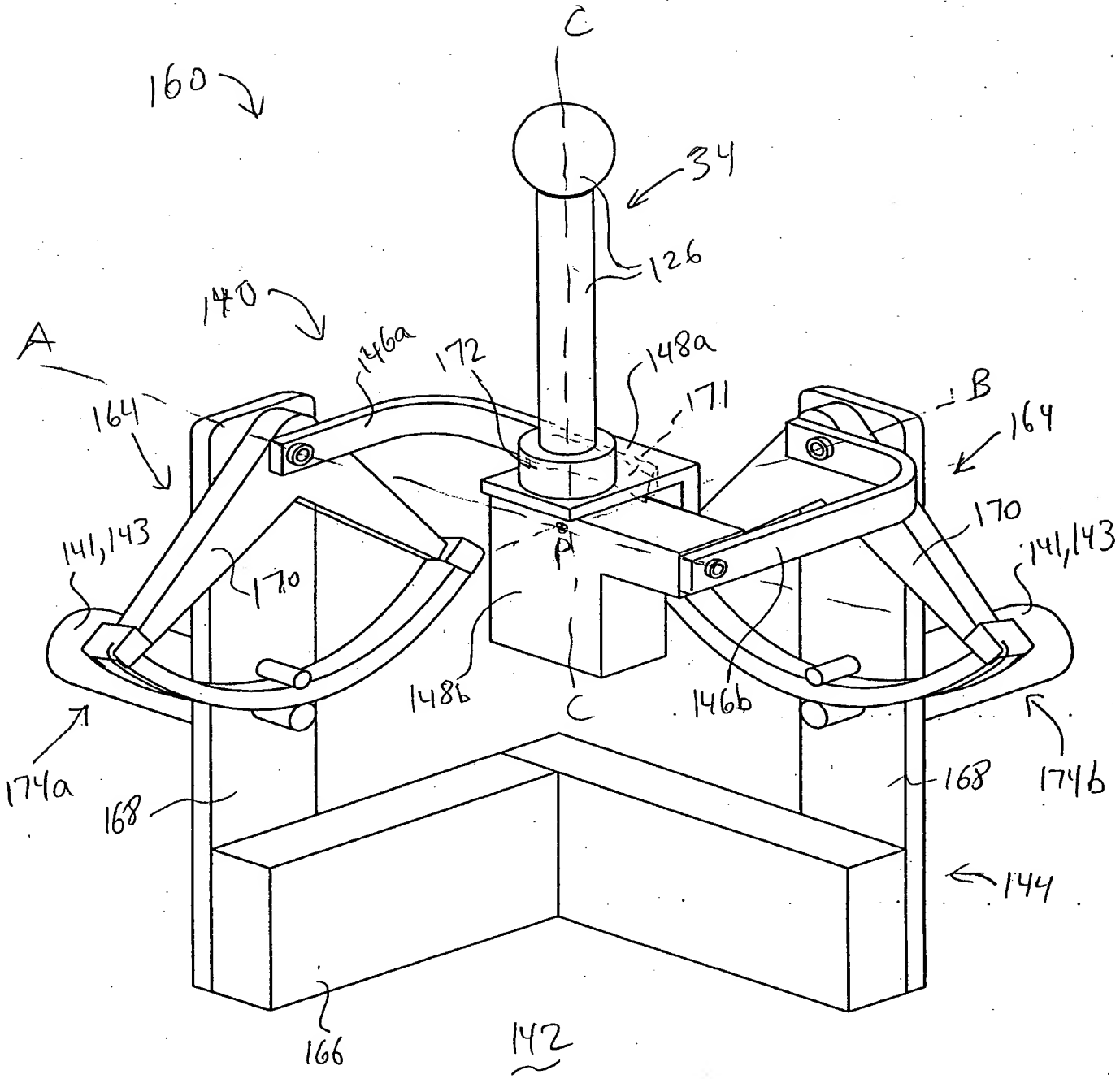

160
C
34
126
140
A
146a
172
148a
171
B
164
164
141,143
170
170
141,143
P
148b
C
146b
174a
174b
168
168
144
166
142

Figure 7

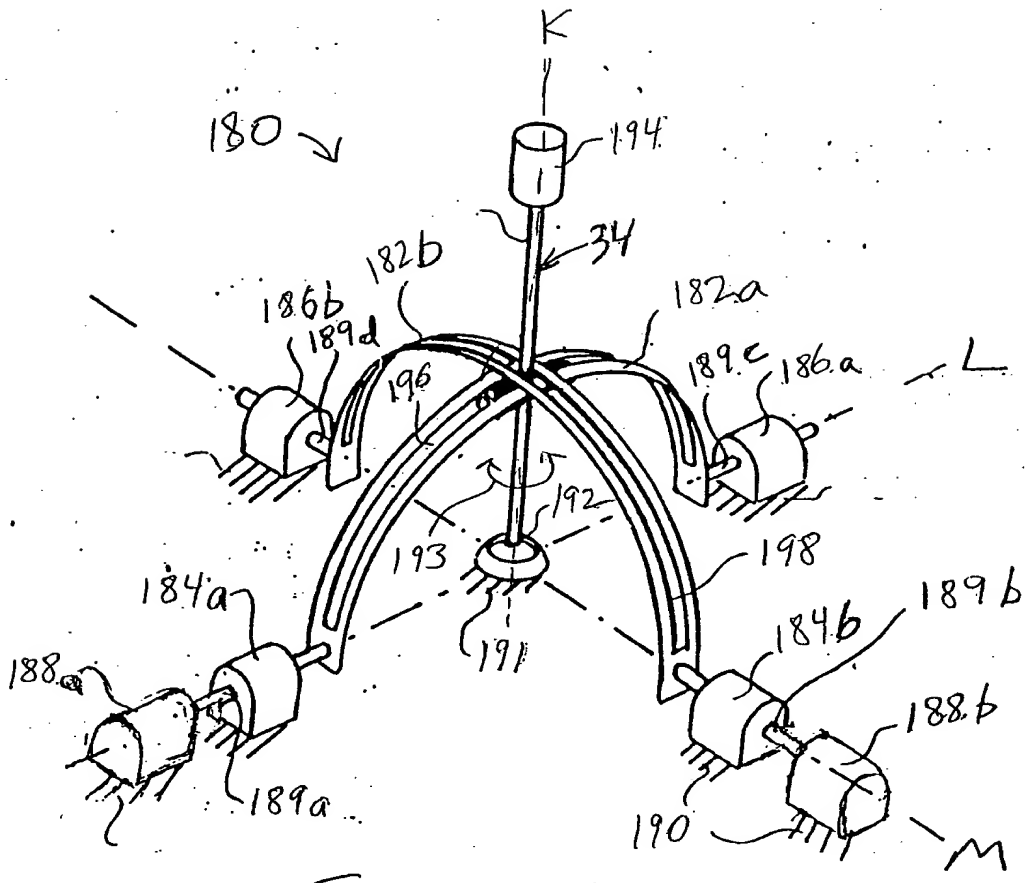

K
180
194
34
182b
186b
189d
182a
189c
186a
L
196
192
193
198
184a
189b
191
184b
188a
188b
189a
190
M

Figure 8

300

RATE CONTROL COMMANDS

FORCE (302)	EXAMPLE OF COMMAND AND PARAMETERS (304) (306) (308)	SUBCLASS (310)
RESTORING	R_FORCE (MAGNITUDE, DURATION, STYLE, DEADBAND)	CONDITION
RESTORING SPRING	R_SPRING (COEFFICIENT, DURATION, STYLE, DEADBAND)	CONDITION
SLUGGISH STICK	SLUG (COEFFICIENT, DURATION, STYLE)	CONDITION
UNSTABLE	UNSTABLE (MAGNITUDE, DURATION, STYLE)	CONDITION
VECTOR	V_FORCE (MAGNITUDE, DURATION, DIRECTION)	OVERLAY
VIBRATION	V_VIBRATE (MAGNITUDE, DURATION, DIRECTION, FREQUENCY, STYLE)	OVERLAY
WOBBLE	WOBBLE (MAGNITUDE, DURATION, STYLE)	OVERLAY
BUTTON	B_FORCE (MAGNITUDE, DURATION, DIRECTION, BUTTON, AUTOFIRE)	OVERLAY/CONDITION
JOLT	JOLT (MAGNITUDE, DURATION, DIRECTION)	OVERLAY

FIGURE 9

09756547 - 010501

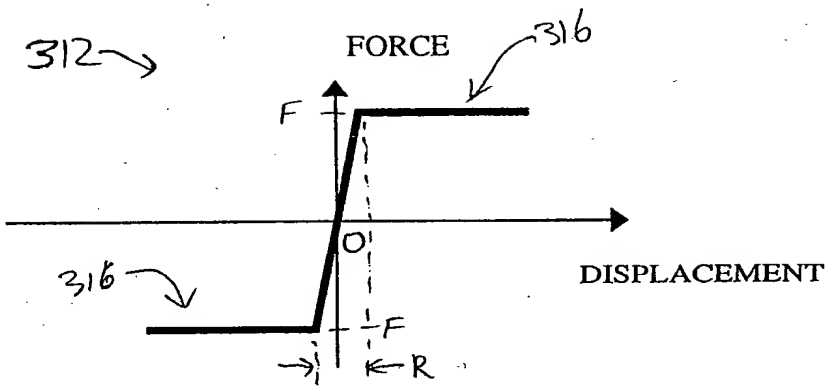


FIGURE 10a

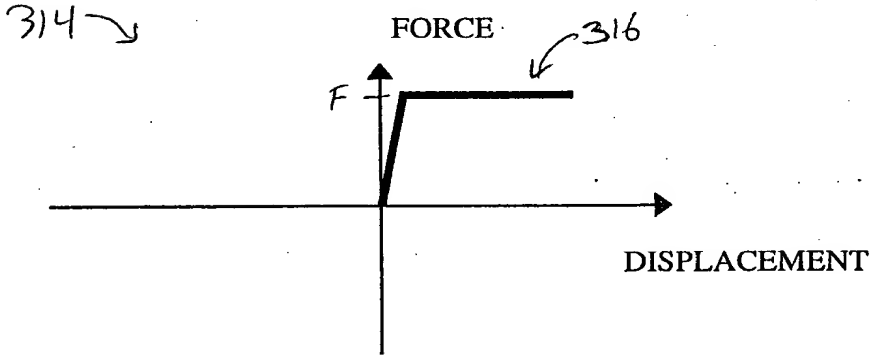


FIGURE 10b

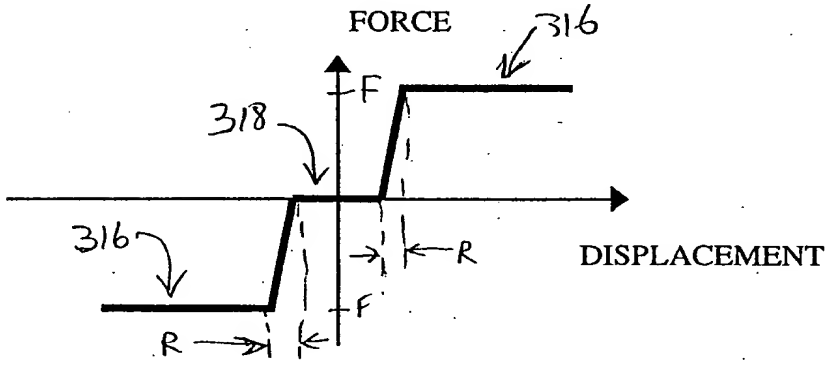


FIGURE 10c

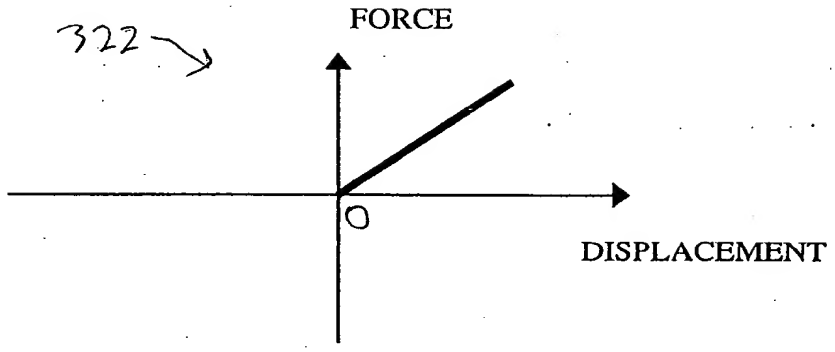


FIGURE 11b

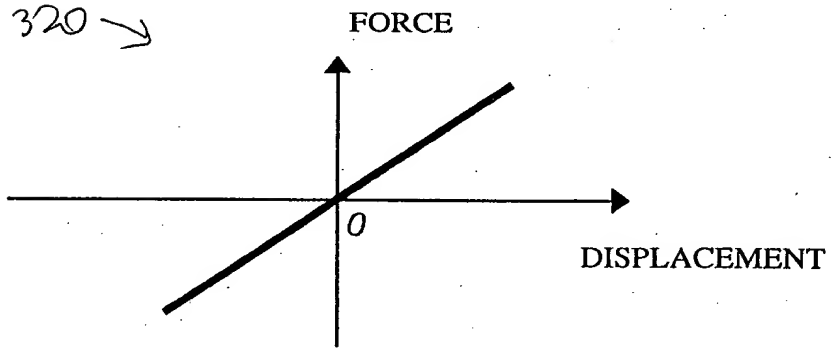


FIGURE 11a

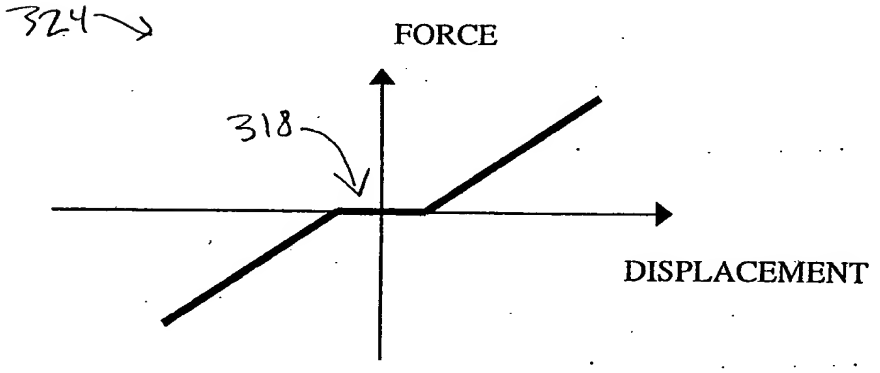


FIGURE 11c

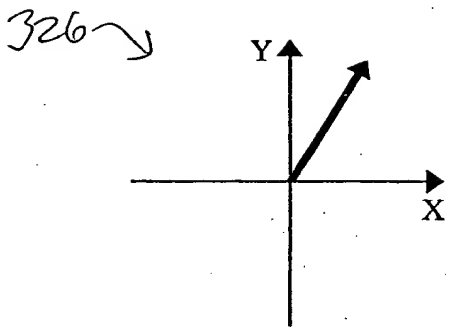


FIGURE 12

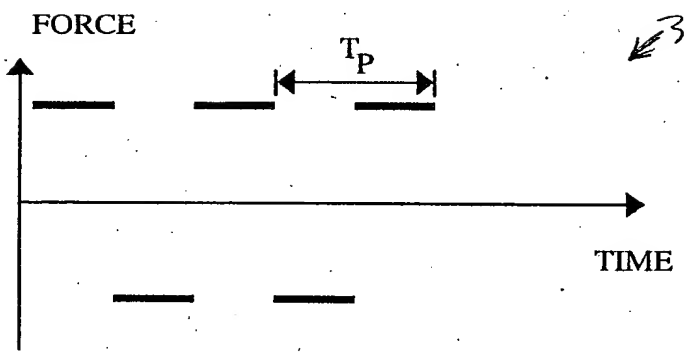


FIGURE 13a

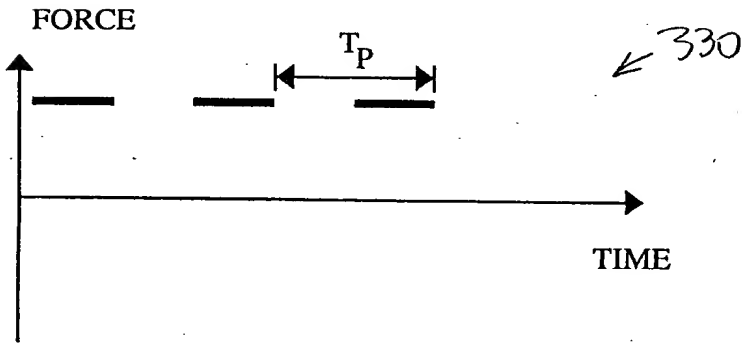


FIGURE 13b

334

332

POSITION CONTROL COMMANDS

FORCE	EXAMPLE OF COMMAND AND PARAMETERS (336) (338) (340)
VECTOR	P_FORCE (MAGNITUDE, DIRECTION)
GROOVE	GROOVE (MAGNITUDE, STYLE, SNAP-DISTANCE)
DIVOT	DIVOT (MAGNITUDE, STYLE, SNAP-DISTANCE)
TEXTURE	TEXTURE (MAGNITUDE, DENSITY, STYLE)
BARRIER	X_BARRIER (MAGNITUDE, LOCATION, SNAP-DISTANCE)
FIELD	FIELD (MAGNITUDE, ORIGIN, SENSE)
PADDLE	PADDLE (MASS, GRAVITY, COMPLIANCE, SENSE)
BUTTON	BUTTON (MAGNITUDE, DIRECTION, BUTTON, AUTOFIRE)

FIGURE 14

09756547 .010301

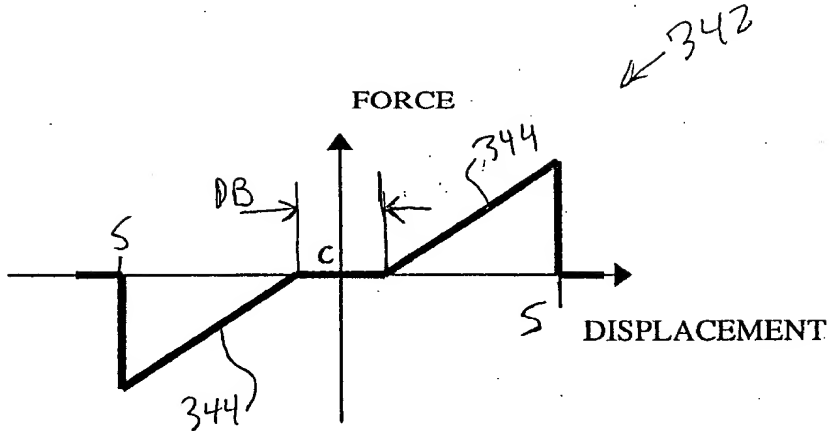


FIGURE 15

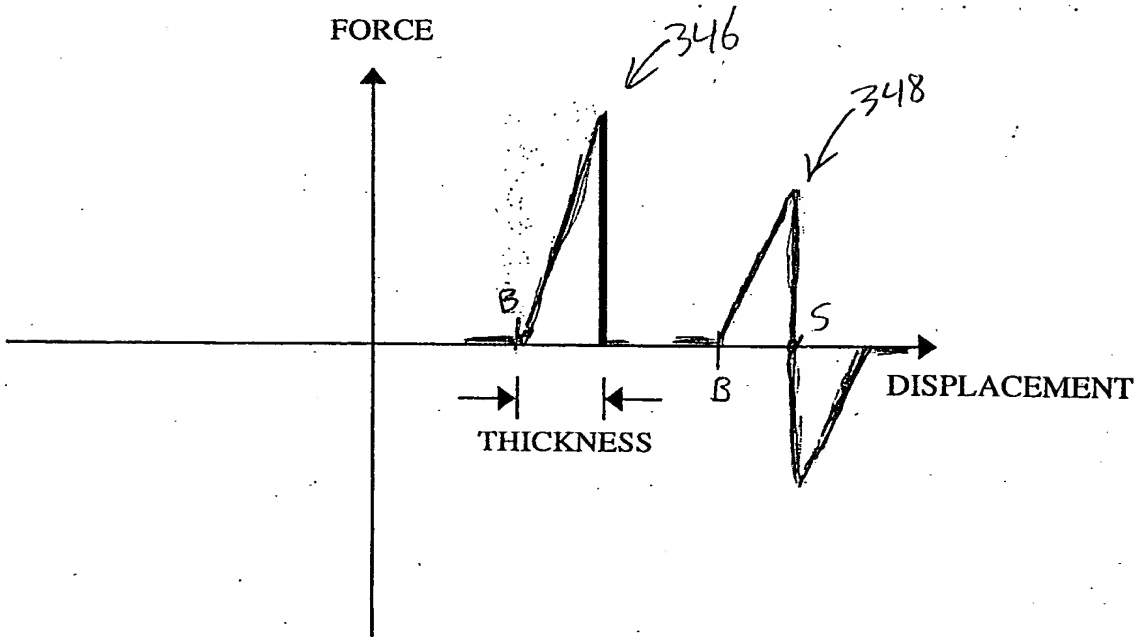


FIGURE 16

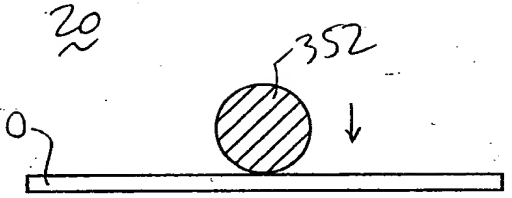


Fig. 17a

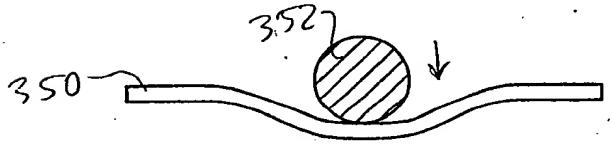


Fig. 17b

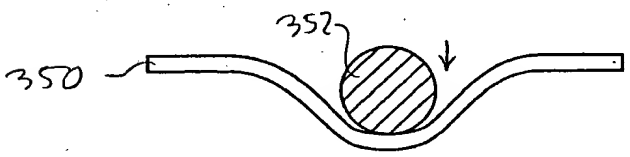


Fig. 17c

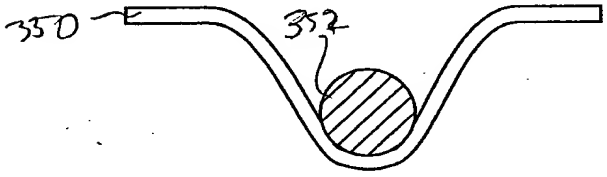


Fig. 17d

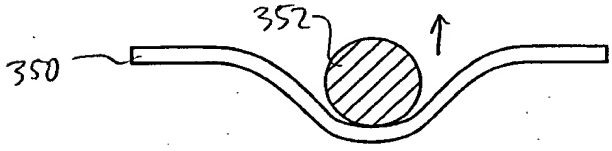


Fig. 17e

Fig. 17f

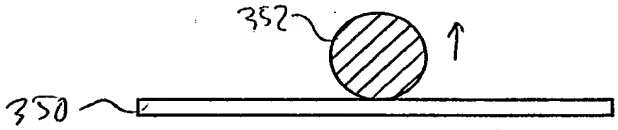


Fig. 17g

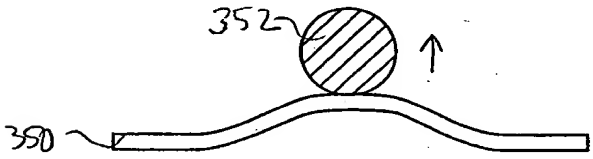


Fig. 17h

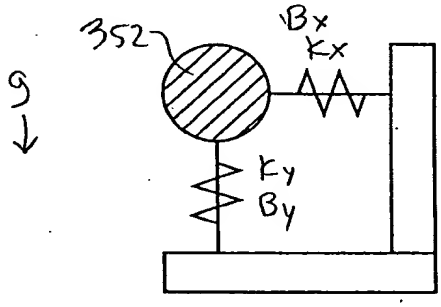


Fig. 17i

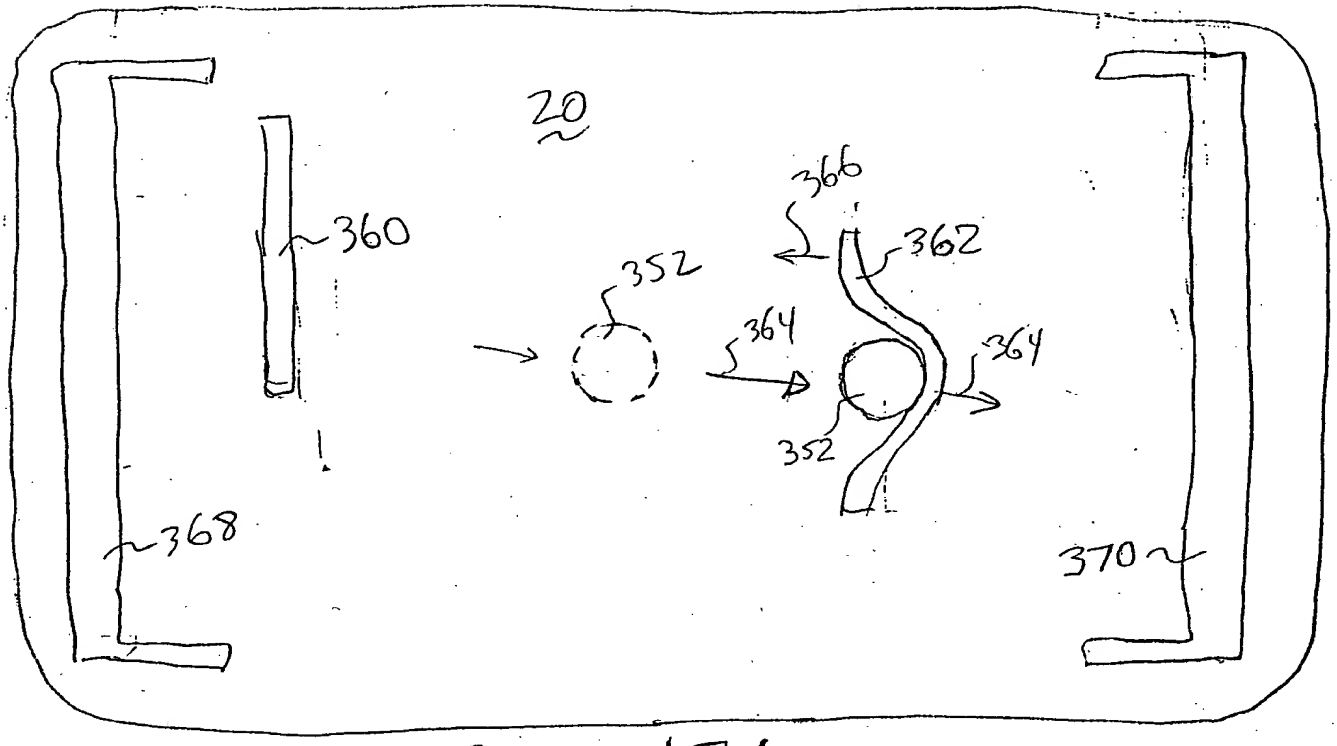


Figure 17j

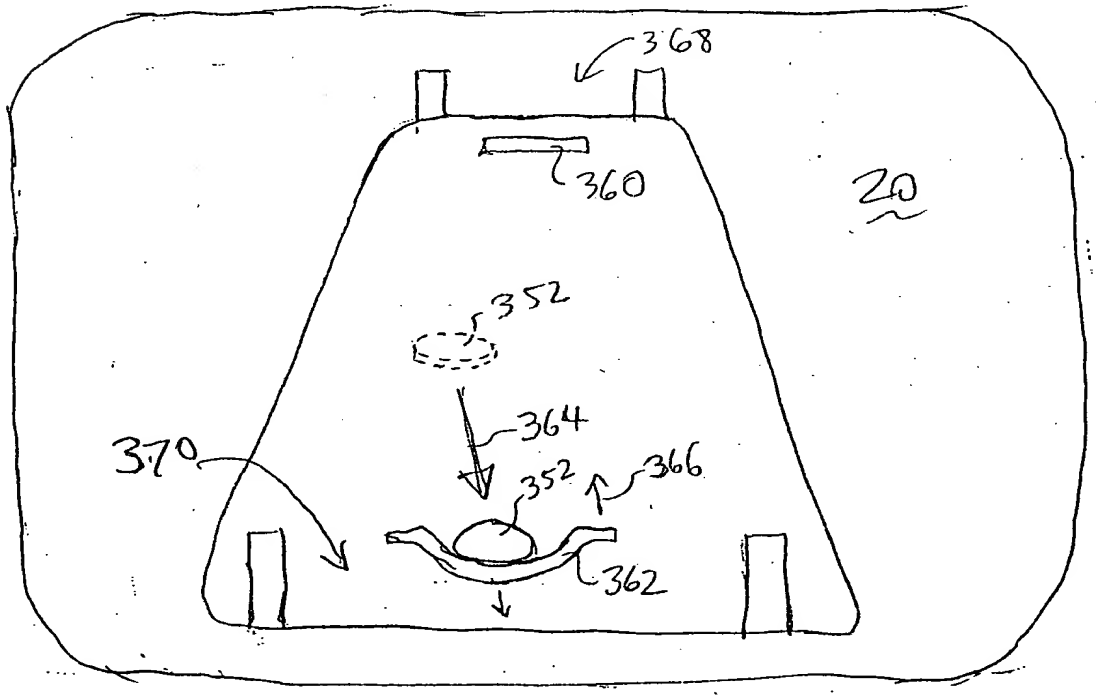


Figure 17k

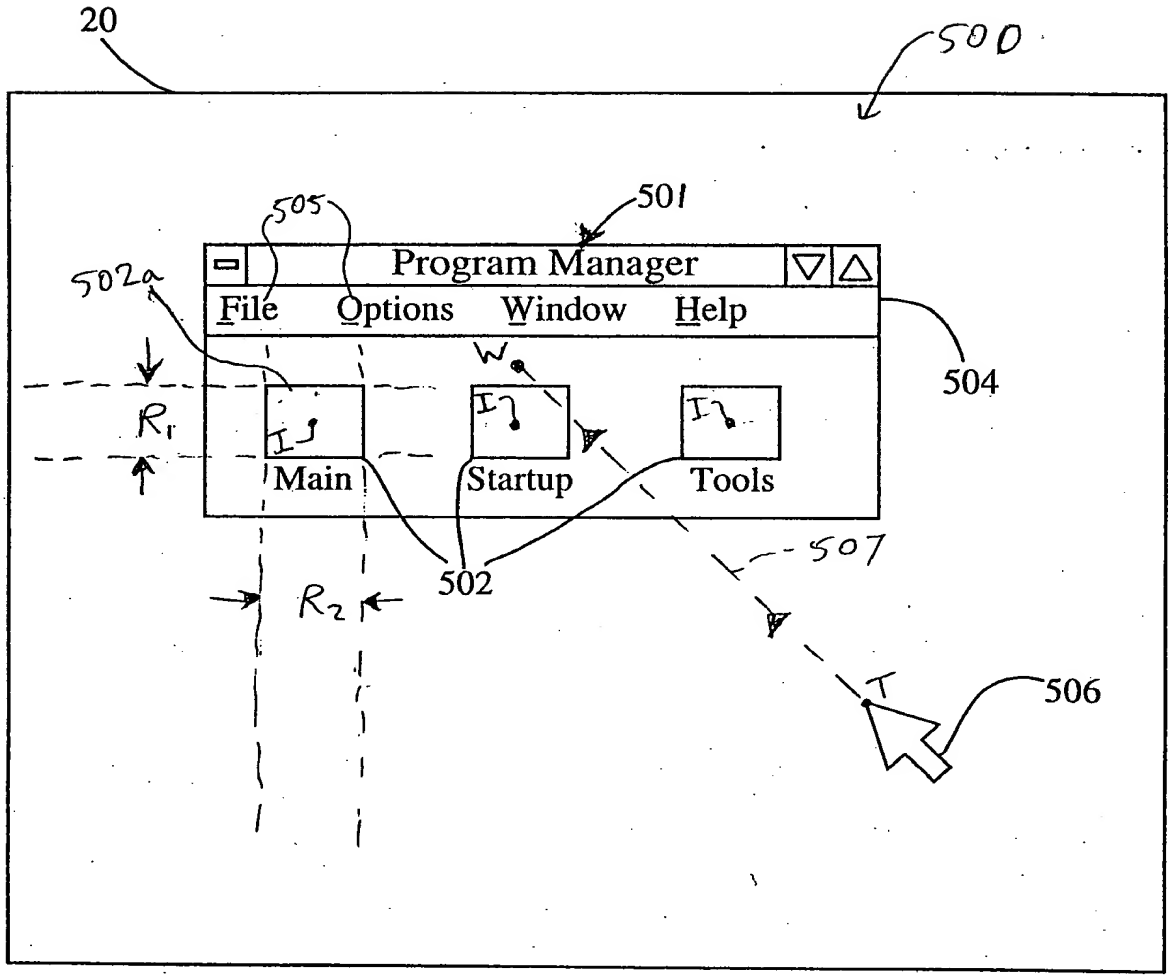

20
500
501
505
Program Manager
File
Options
Window
Help
504
502a
W
R_1
Main
Startup
Tools
502
507
R_2
T
506

Figure 18

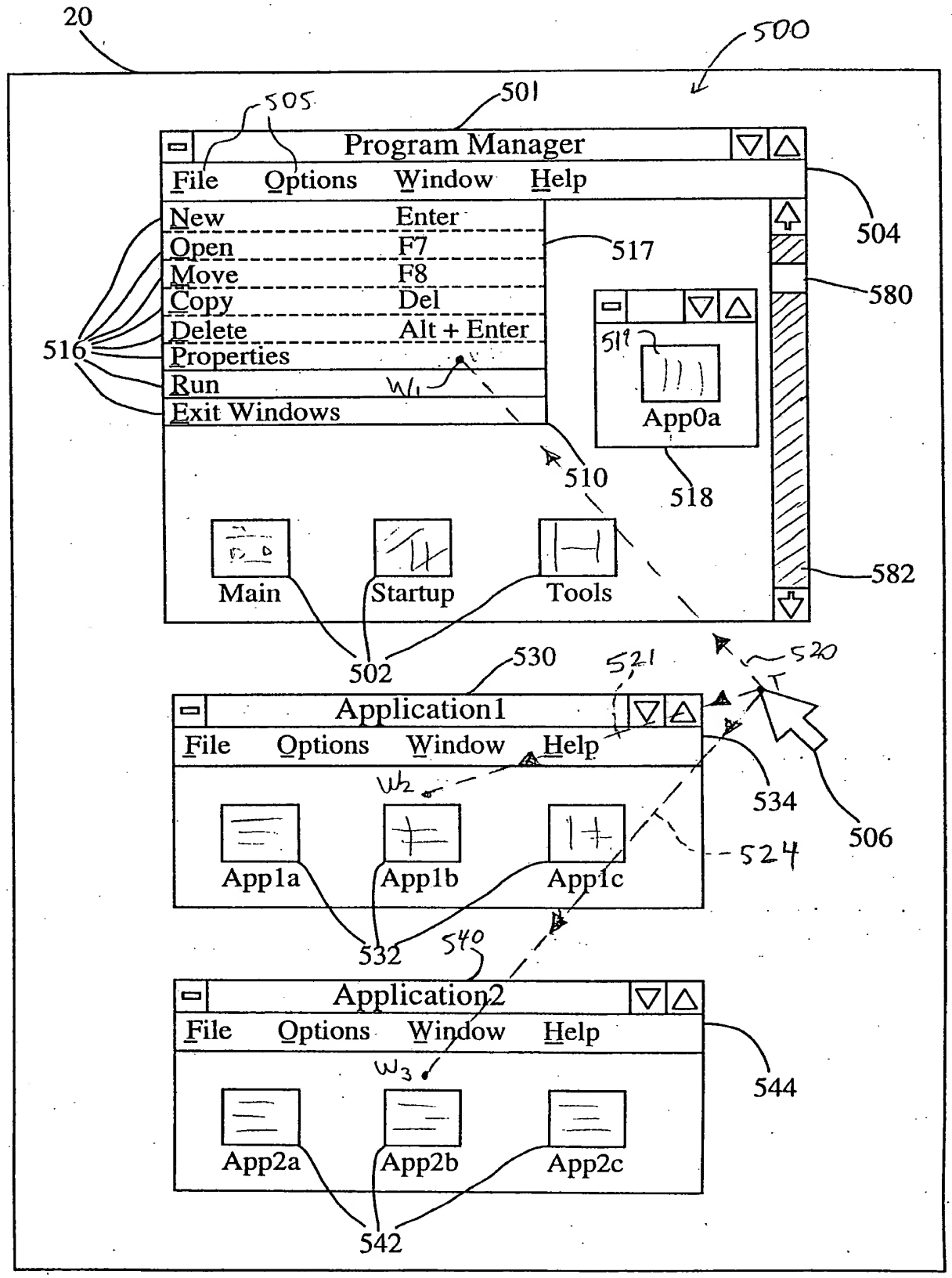

20
500
505
501
Program Manager
File Options Window Help
504
New Enter
Open F7
Move F8
Copy Del
Delete Alt + Enter
Properties
Run
Exit Windows
516
517
580
511
App0a
510
518
Main
Startup
Tools
582
502
530
521
520
Application1
File Options Window Help
534
506
524
App1a
App1b
App1c
532
540
Application2
File Options Window Help
544
App2a
App2b
App2c
542

Figure 19

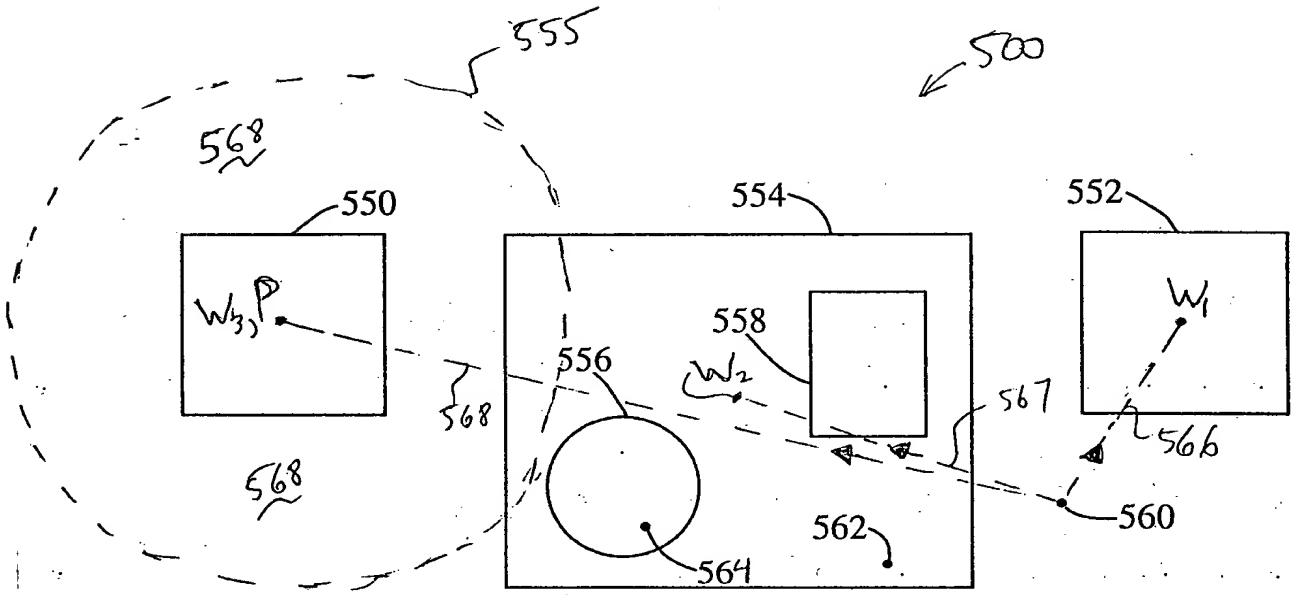


Figure 20a

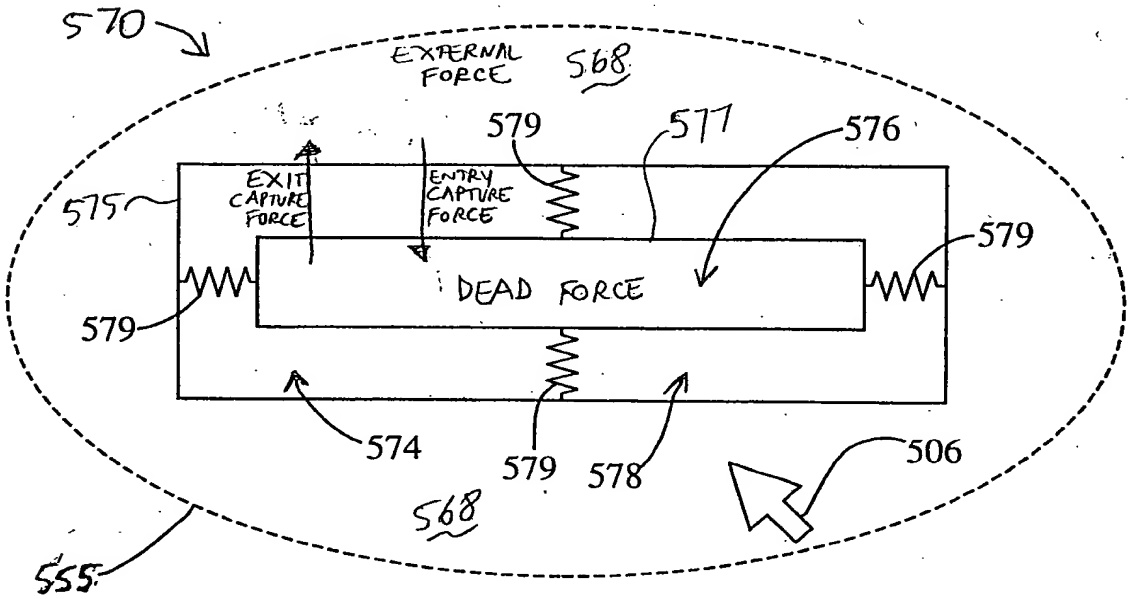


Figure 20b

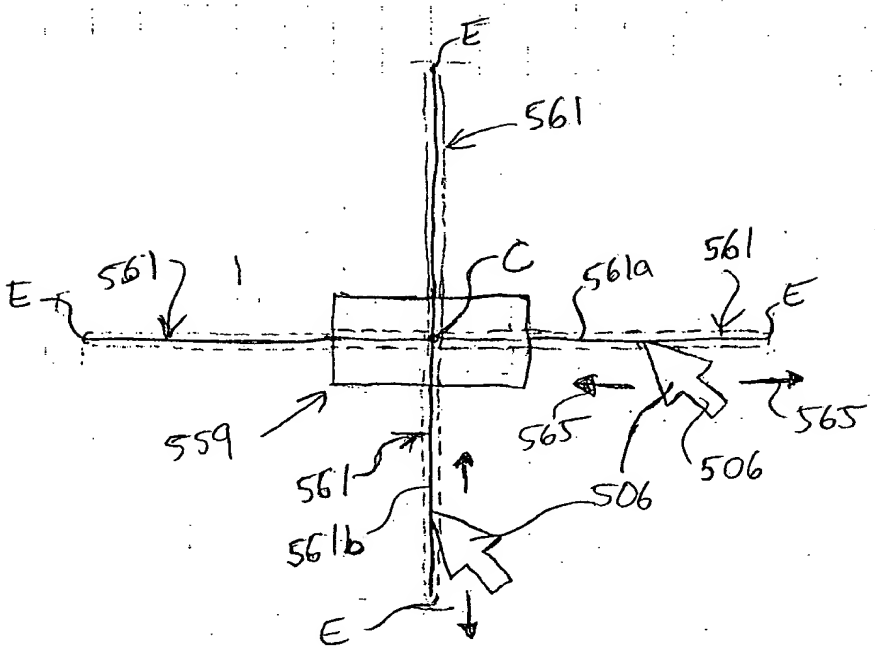


Figure 20c

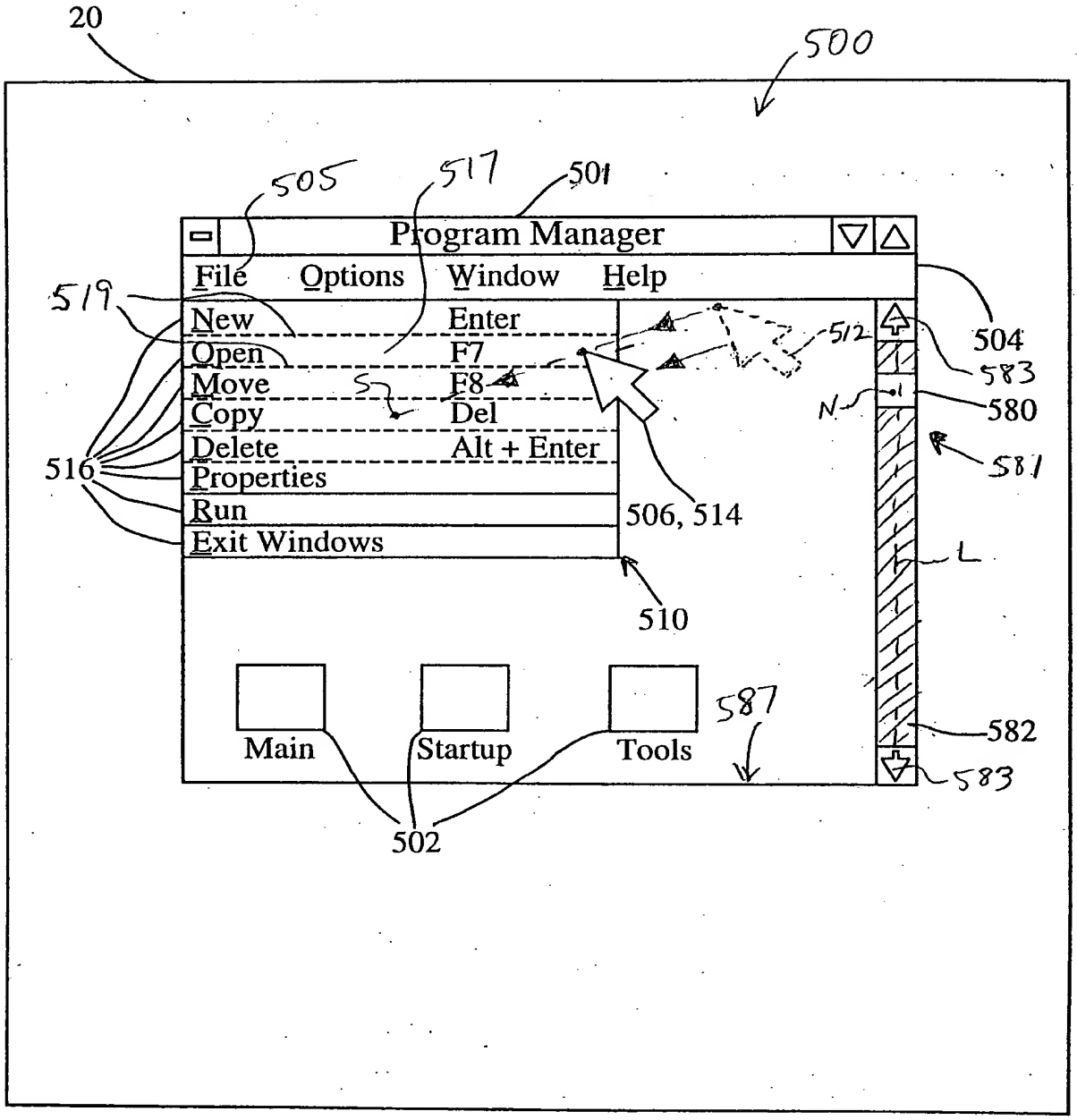

20
500
505
517
501
Program Manager
File Options Window Help
519
New Enter
Open F7
Move F8
Copy Del
Delete Alt + Enter
Properties
Run
Exit Windows
516
506, 514
510
512
504
583
580
581
L
582
583
Main
Startup
Tools
587
502

Figure 2

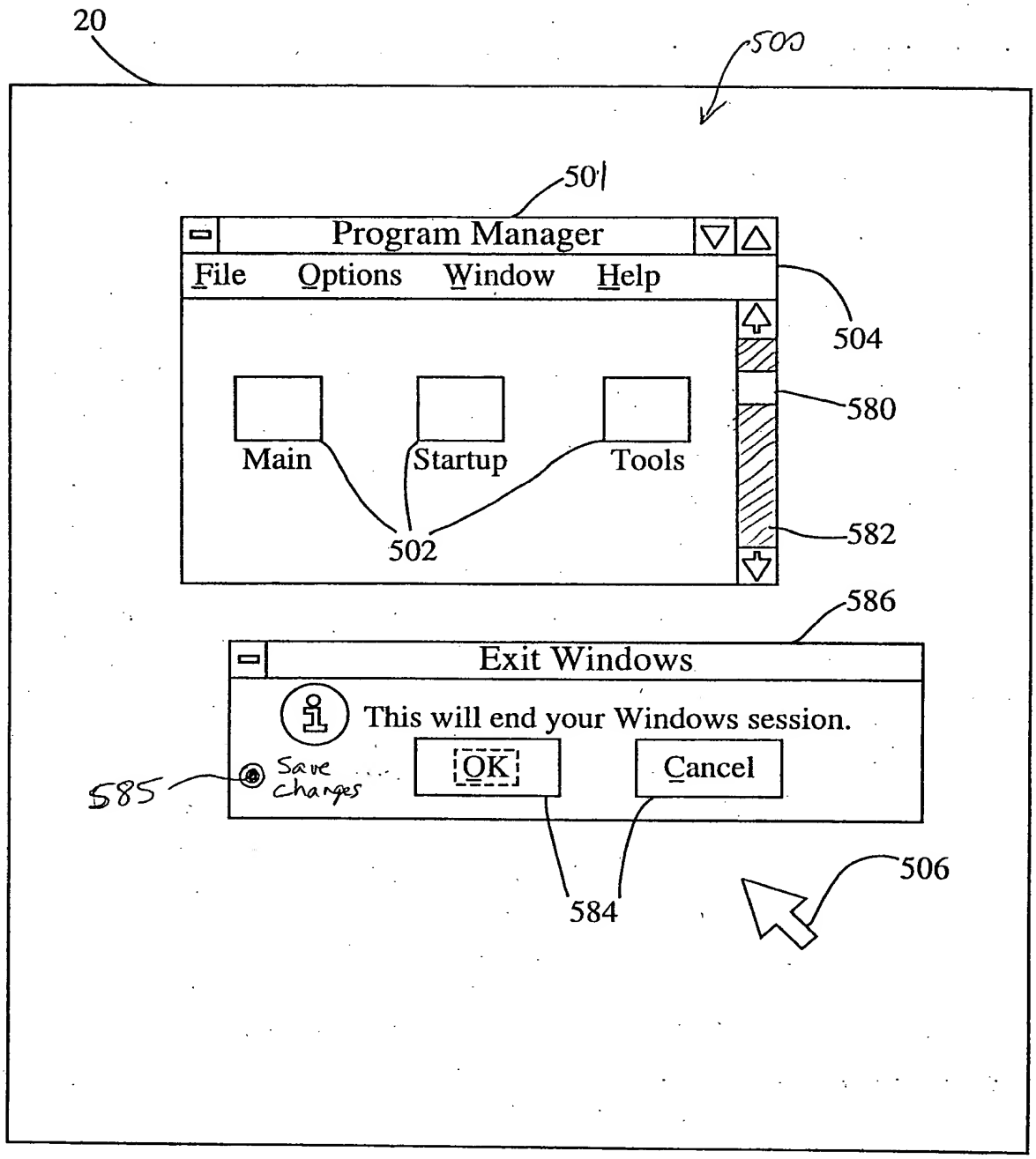

20
500
501
Program Manager
File
Options
Window
Help
504
Main
Startup
Tools
580
582
502
586
Exit Windows
This will end your Windows session.
585
Save changes
OK
Cancel
584
506

Figure 22

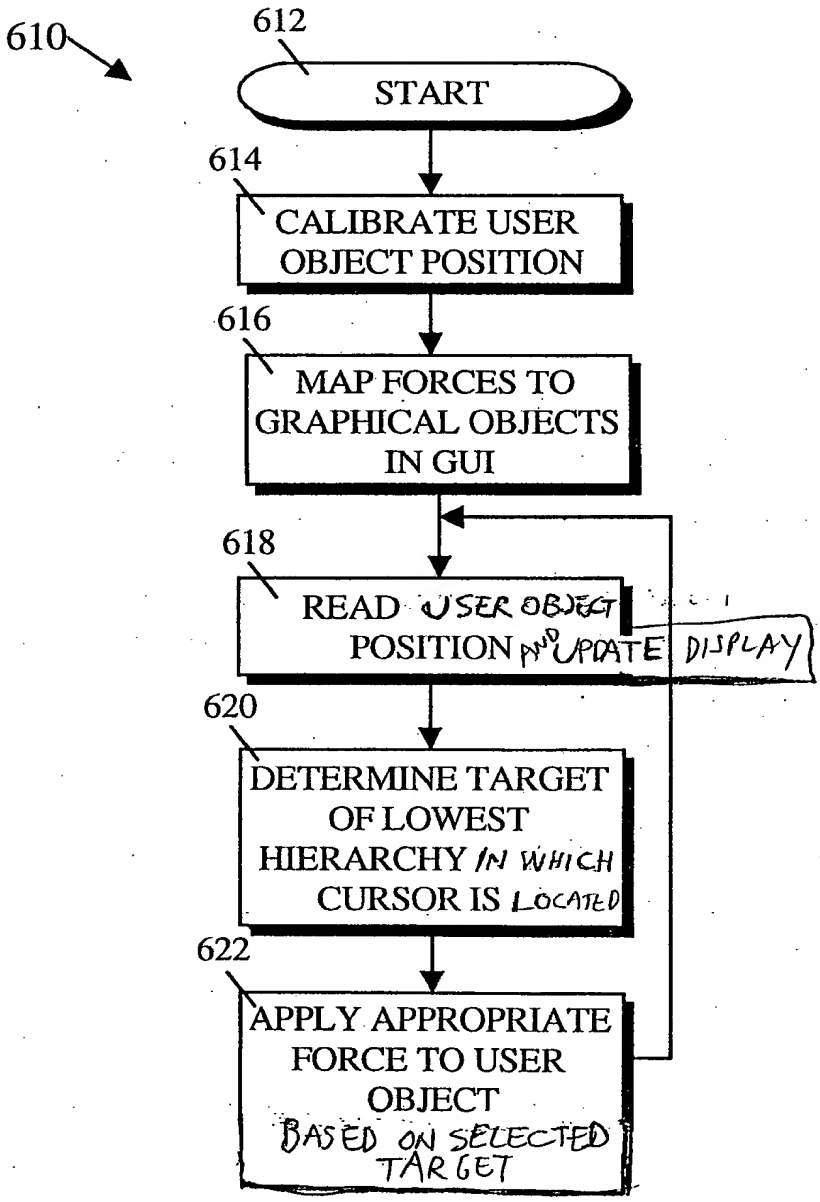

610
612
START
614
CALIBRATE USER OBJECT POSITION
616
MAP FORCES TO GRAPHICAL OBJECTS IN GUI
618
READ USER OBJECT POSITION AND UPDATE DISPLAY
620
DETERMINE TARGET OF LOWEST HIERARCHY IN WHICH CURSOR IS LOCATED
622
APPLY APPROPRIATE FORCE TO USER OBJECT BASED ON SELECTED TARGET

Figure 23

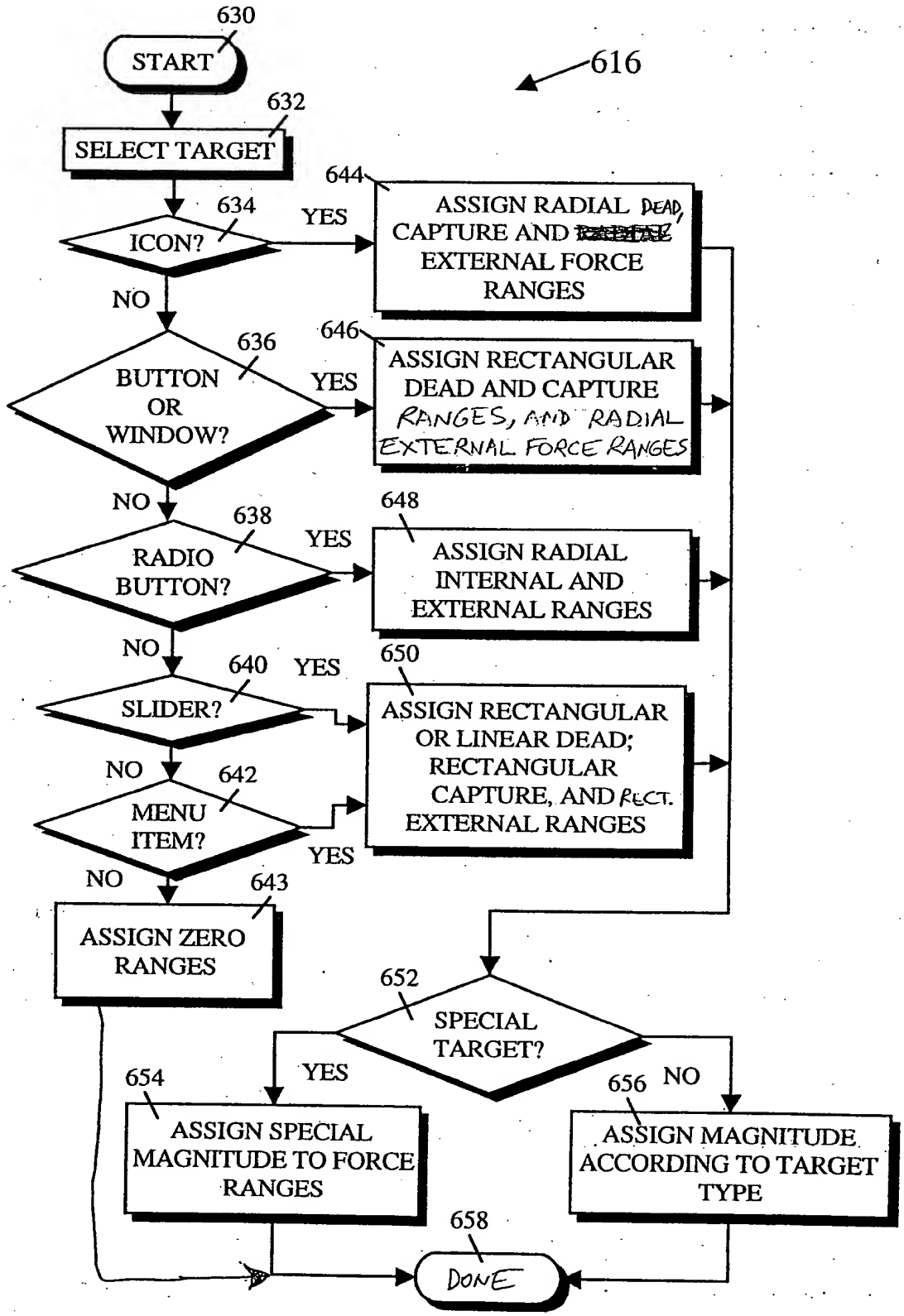

630
START
616
632
SELECT TARGET
644
634
ICON?
YES
ASSIGN RADIAL DEAD, CAPTURE AND EXTERNAL FORCE RANGES
NO
646
636
BUTTON OR WINDOW?
YES
ASSIGN RECTANGULAR DEAD AND CAPTURE RANGES, AND RADIAL EXTERNAL FORCE RANGES
NO
648
638
RADIO BUTTON?
YES
ASSIGN RADIAL INTERNAL AND EXTERNAL RANGES
NO
650
640
YES
SLIDER?
ASSIGN RECTANGULAR OR LINEAR DEAD; RECTANGULAR CAPTURE, AND RECT. EXTERNAL RANGES
NO
642
MENU ITEM?
YES
NO
643
ASSIGN ZERO RANGES
652
SPECIAL TARGET?
YES
NO
654
ASSIGN SPECIAL MAGNITUDE TO FORCE RANGES
656
ASSIGN MAGNITUDE ACCORDING TO TARGET TYPE
658
DONE

Figure 24

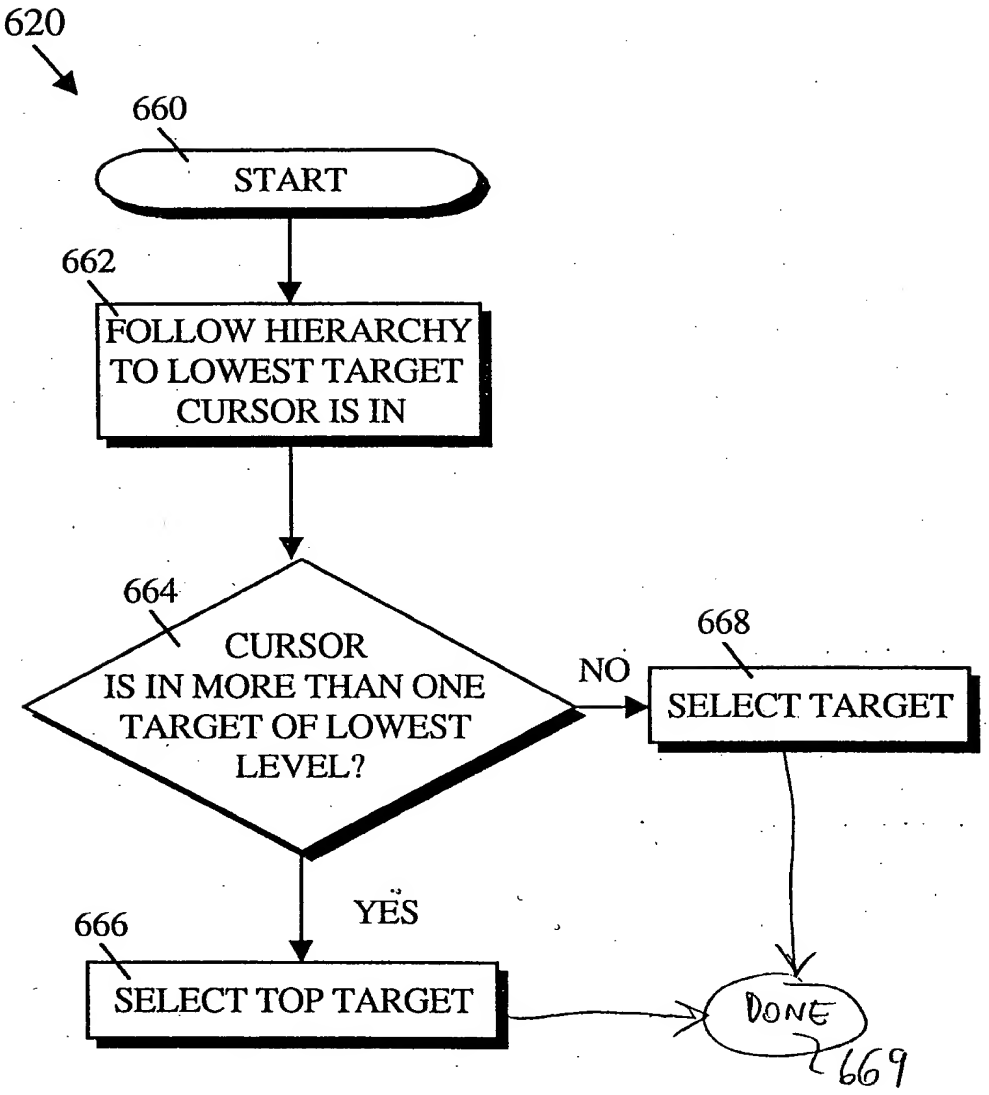

620
660
START
662
FOLLOW HIERARCHY TO LOWEST TARGET CURSOR IS IN
664
CURSOR IS IN MORE THAN ONE TARGET OF LOWEST LEVEL?
NO
668
SELECT TARGET
YES
666
SELECT TOP TARGET
DONE
669

FIGURE 25

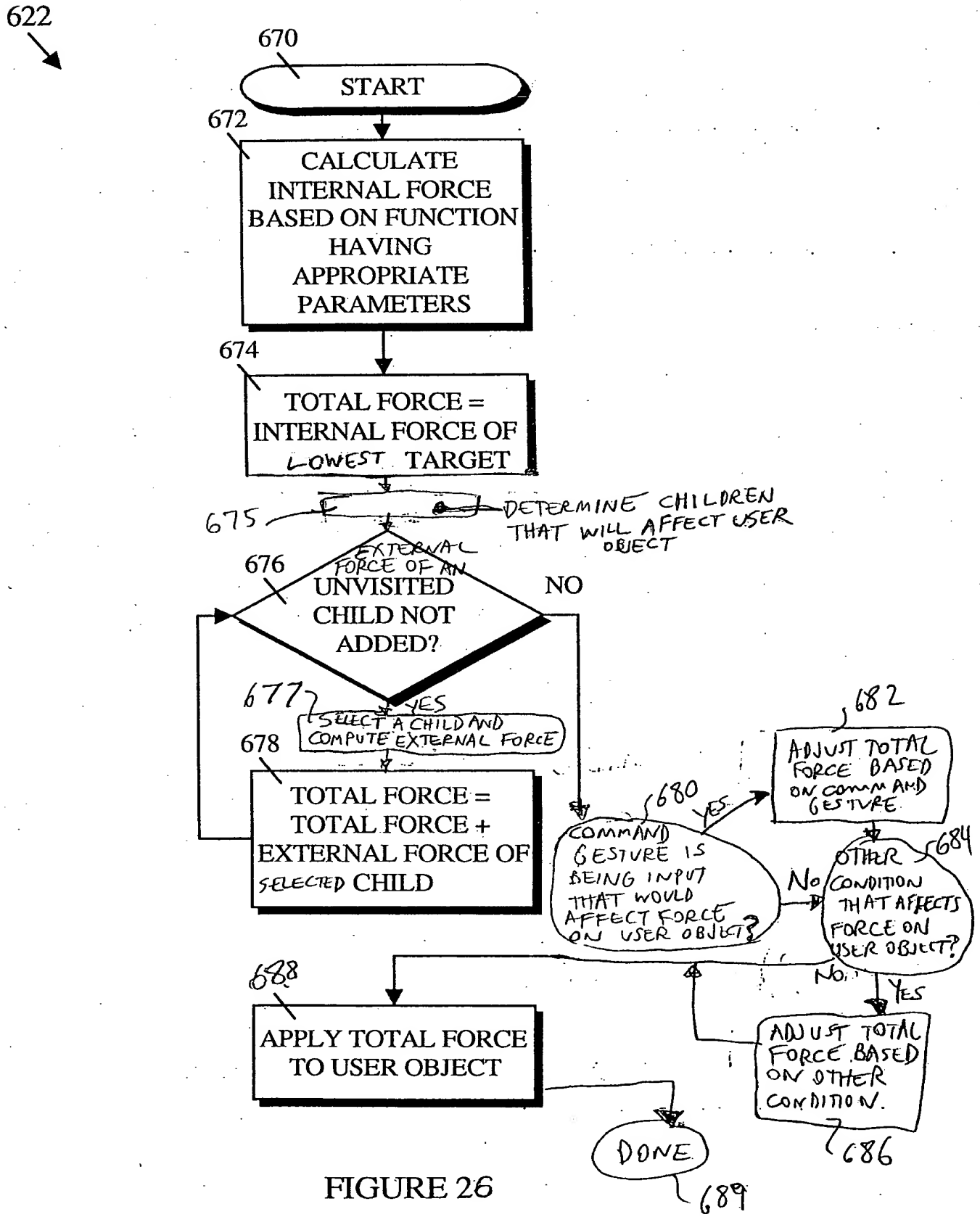

622
670
START
672
CALCULATE INTERNAL FORCE BASED ON FUNCTION HAVING APPROPRIATE PARAMETERS
674
TOTAL FORCE = INTERNAL FORCE OF LOWEST TARGET
675
DETERMINE CHILDREN THAT WILL AFFECT USER OBJECT
676
EXTERNAL FORCE OF AN UNVISITED CHILD NOT ADDED?
NO
YES
677
SELECT A CHILD AND COMPUTE EXTERNAL FORCE
678
TOTAL FORCE = TOTAL FORCE + EXTERNAL FORCE OF SELECTED CHILD
680
COMMAND GESTURE IS BEING INPUT THAT WOULD AFFECT FORCE ON USER OBJECT?
YES
682
ADJUST TOTAL FORCE BASED ON COMMAND GESTURE
No
684
OTHER CONDITION THAT AFFECTS FORCE ON USER OBJECT?
No
YES
686
ADJUST TOTAL FORCE BASED ON OTHER CONDITION.
688
APPLY TOTAL FORCE TO USER OBJECT
DONE
689

FIGURE 26

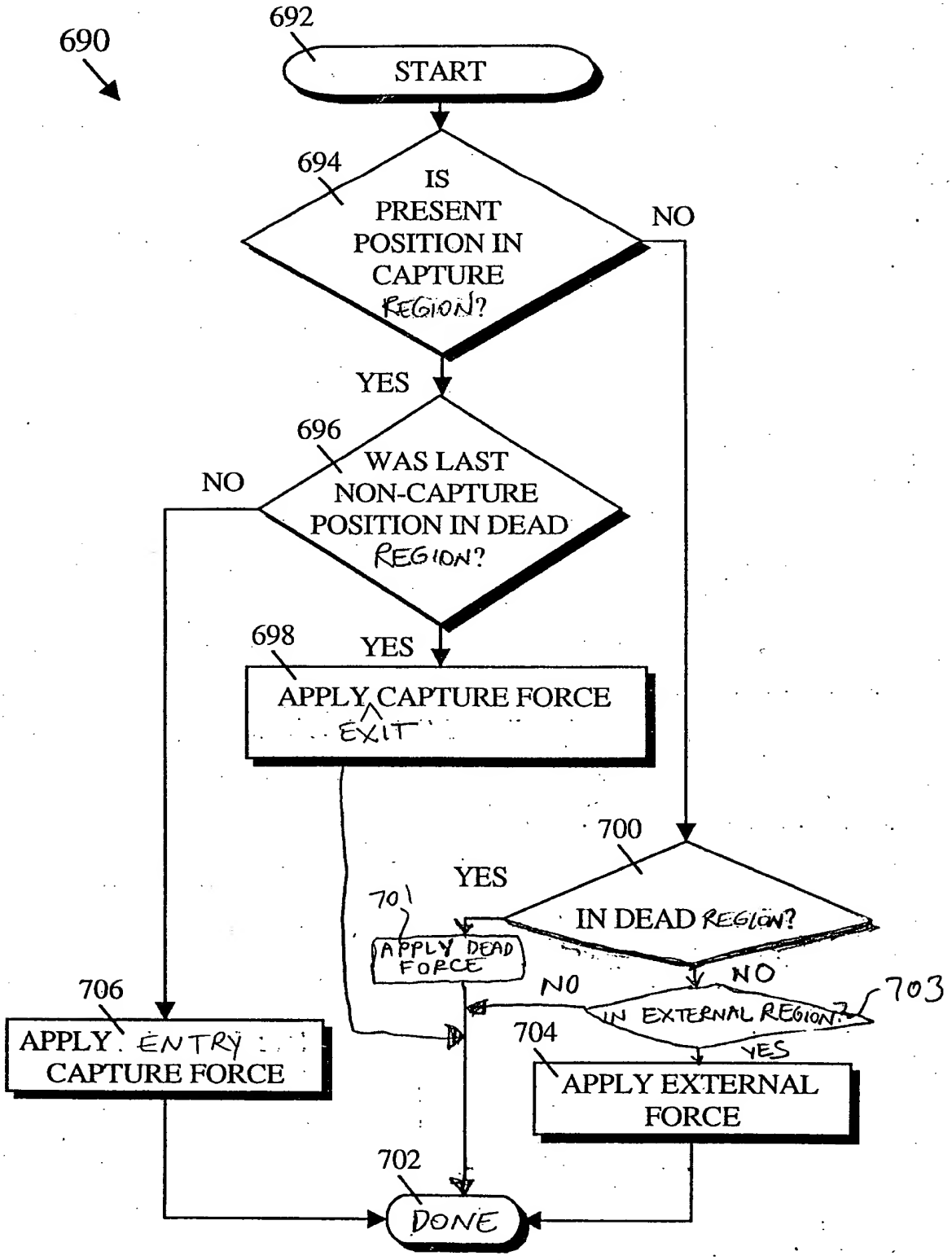

690
692
START
694
IS PRESENT POSITION IN CAPTURE REGION?
NO
YES
696
WAS LAST NON-CAPTURE POSITION IN DEAD REGION?
NO
698
YES
APPLY CAPTURE FORCE
EXIT
700
YES
701
IN DEAD REGION?
APPLY DEAD FORCE
NO
NO
703
IN EXTERNAL REGION?
YES
704
APPLY EXTERNAL FORCE
706
APPLY ENTRY CAPTURE FORCE
702
DONE

FIGURE 27